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AUDITORY DISCRIMINATION ABILITIES AND BEGINNING READING ACHIEVEMENT.

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THE RELATIONSHIPS BETWEEN PREREADING MEASURES OF AUDITORY DISCRIMINATION AND READING ACHIEVEMENT AT THE END OF FIRST GRADE ARE REPORTED. DATA WERE GATHERED ON 632 PUPILS IN THE MINNEAPOLIS PUBLIC SCHOOLS WHO WERE ADMINISTERED SEVEN TESTS OF AUDITORY DISCRIMINATION SELECTED FROM PUBLISHED READING READINESS TESTS AND A GROUP INTELLIGENCE TEST AT THE BEGINNING OF FIRST GRADE. TWO TESTS OF READING ACHIEVEMENT WERE GIVEN AT THE END OF THE YEAR. RELATIONSHIPS WERE ASSESSED BY MEANS OF CORRELATION AND MULTIPLE REGRESSION ANALYSIS. ANALYSIS OF DIFFERENCES OF MEANS WAS DONE THROUGH USE OF T TESTS. INTERCORRELATIONS AMONG AUDITORY DISCRIMINATION MEASURES AND BETWEEN EACH MEASURE AND SUBSEQUENT READING ACHIEVEMENT WERE UNIFORMLY LOW. INTELLIGENCE WAS SIGNIFICANTLY RELATED TO READING ACHIEVEMENT. SIGNIFICANT SEX DIFFERENCES IN PERFORMANCE ON THREE OF THE AUDITORY DISCRIMINATION TESTS AND ON BOTH OF THE READING TESTS FAVORED THE GIRLS. THE CONCLUSIONS AND EDUCATIONAL IMPLICATIONS ARE DISCUSSED. TABLES AND REFERENCES ARE INCLUDED. (MD)

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Auditory discrimination abilities and beginning reading achievement

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REPORTS RELATIONSHIPS between pre-reading measures of auditory discrimination and reading achievement at the end of the first grade. Seven measures of auditory discrimination and a group intelligence test were administered at the beginning of first grade, and two measures of reading achievement were given at the end of the first grade. Complete data were gathered on 632 pupils. Relationships were assessed by means of correlation analysis and multiple regression. Results showed intercorrelations among auditory discrimination measures and between each measure and subsequent reading achievement to be uniformly low with few reaching .40. Five of the seven auditory discrimination measures made a significant contribution to a multiple regression equation which was designed to predict reading achievement. In addition, intelligence was significantly related to reading achievement. Nevertheless, variation in performance on the auditory discrimination and intelligence measures accounted for less than half of the variation in performance on the reading measures. Other findings included significant sex differences in performance on three of the auditory discrimination tests and on both reading tests. All such differences favored girls.

Capacités de discernement auditif et succés pour le début de la lecture

CETTE ÉTUDE donne un compte rendu des relations entre les mesures pré-lecturales de discernement auditif et l'aptitude d'avoir appris à lire à la fin de la première année. Sept mesures de discernement auditif et un groupe d'épreuves d'intelligence fut donné au début de la première année d'école et deux mesures d'accomplissement lectural furent donnés à la fin de la première année d'école. Des données complètes furent établies sur 632 élèves. Les relations furent examinées par une analyse corrélative de Pearson et par rebroussement multiple. Les resultats

montrent des intercorrélations relativement faibles, atteignant, dans quelques cas 0.40, parmi les mesures du discernement auditif et entre chaque mesure et l'accomplissement subséquent d'avoir appris à lire. Cinq des sept mesures de discernement auditif donnèrent une contribution significative à une equation de rebroussement multiple qui avait été conçue pour prédire l'accomplissement d'aprendre à lire. De plus l'intelligence a été reliée d'une manière significative avec l'accomplissement d'apprendre à lire. Cependant des variations dans l'action du discernement auditif et les mesures d'intelligence comptent pour moins de la moitié des variations de mesures pour apprendre à lire. Parmi d'autres découvertes citons une différence significative entre les deux sexes dans l'accomplissement des trois épreuves de discernement auditif et de deux épreuves de lecture. Toutes ces différences favorisent les filles.

Habilidades de discriminación auditiva y rendimiento de lectura de primer grado

ESTE ESTUDIO informa sobre la relación entre las medidas de discriminación auditiva antes de aprender a leer y el rendimiento de lectura al terminar el primer grado. Al comenzar el primer grado se hicieron siete medidas de discriminación auditiva y un examen de inteligencia del grupo, y se hicieron dos medidas del rendimiento de lectura al terminar el primer grado. Se reunieron datos sobre 632 estudiantes. Se evaluó la relación por medio del análisis correlacional de Pearson y regresión múltiple. Los resultados mostraron que las intercorrelaciones entre las medidas de discriminación auditiva y entre cada medida y el rendimiento de lectura subsiguiente eran uniformemente bajas con muy pocas llegando a .40. Cinco de las siete medidas de discriminación auditiva contribuyeron significativamente a la ecuación de regresión múltiple que se diseñó para predecir el rendimiento de lectura. Además, la inteligencia apareció significativamente relacionada con el rendimiento de lectura. No obstante, la diferencia en capacidad de discriminación auditiva y las medidas de inteligencia llegaron a menos de la mitad de las variaciones en comportamiento en las medidas de lectura. Otros descubrimientos incluyeron una diferencia significativa de sexo en la capacidad en tres de los exámenes de discriminación auditiva y en los dos exámenes de lectura. Todas estas diferencias fueron en favor de las niñas.

The problem of identifying the readiness factors which are related to success in first-grade reading achievement is not new. Following Thorndike's (1914) interest in readiness for learning in general and his formulation of the "law of readiness," increasing attention was given to the study of readiness for the specific task of reading. Publication in 1925 of the Twenty-Fourth Yearbook of the National Society for the Study of Education provided further impetus in this direction with its recognition of the problem of reading readiness.

One of the first major studies of reading readiness was conducted by Deputy (1930), who developed a formula for predicting first-grade reading achievement from scores representing mental maturity, certain visual and auditory skills, content comprehension, and recall. As might be expected, this investigation proved to be only a beginning.

Since that early study, other studies have been designed which attempt to isolate those readiness factors apparently related to success in beginning reading. Most investigations have been concerned with such predictive factors as intelligence, various visual characteristics, general maturity, facility in the use of language, and various other related abilities. However, despite the fact that almost all authorities in the field of reading consider auditory discrimination abilities essential to success in beginning reading, relatively little research has been published with respect to the auditory discrimination factor in readiness. Furthermore, little research evidence is available concerning the relationship between various auditory discrimination abilities and proficiency in reading at any grade level. This fact has been pointed out by many researchers in the field of reading throughout the past thirty years. For example, Bond (1935) reported finding few studies in the literature which related auditory acuity and reading achievement. Kennedy (1942, p. 238) concluded that "many of the writers in the field of reading have assumed the relationship between hearing and reading to exist, but have cited little or no evidence for their assumption." An extensive review of the literature pertaining to primary reading instruction led Inglis (1948) to maintain that problems of hearing in relation to reading had seldom been the subject of experimental study. Furthermore, in the words of Traxler and Townsend (1955, p. 6): "Research on the relation of auditory defects to reading ability continued to be meager." Some additional research in the area of auditory discrimination and beginning reading has been conducted

in the past decade, but more must be done.

This study was designed to provide answers to several related questions. First, do boys and girls perform equally well on auditory discrimination measures at the beginning of the first grade and on reading achievement tests at the end of the first grade? Second, to what extent are each auditory discrimination measure, the measure of intelligence, and chronological age related to each other and to word recognition and paragraph reading ability at the end of the first grade? Third, what is the best combination of auditory discrimination measures, intelligence, and chronological age for predicting reading achievement at the end of first grade? Fourth, how effectively can first-grade reading achievement be predicted on the basis of information concerning the pupil's chronological age, performance on the auditory discrimination measures, and the intelligence test utilized in this investigation?

Several unique features not presented in previous research have been incorporated including: *1]* use of a large representative sample of first-grade pupils, 2] administration of a variety of auditory discrimination measures, 3] separate analyses of the data for boys and girls, and *4]* use of multiple regression analysis in the statistical design.

Research on auditory discrimination and reading achievement

Three major types of studies have emerged in the attempt to determine the relationship of ability in auditory discrimination to achievement in reading. These may be described as *1]* comparisons of "good" and "poor" readers with respect to the auditory capabilities of each, 2] correlation studies which assess relationships between auditory discrimination and reading achievement when they are tested simultaneously, and 3] predictive studies which determine relationships between tests of auditory discrimination at the beginning of first grade and reading achievement at the end of first grade or in subsequent grades.

Comparison of good and poor readers

One method of attempting to determine the relation of skill in auditory discrimination to ability in reading has been to investigate

differences in auditory functioning of groups of "good" and "poor" readers. One such technique is the method of matched-pairs wherein pairs of individuals are matched with respect to sex, intelligence, visual acuity or perception, and as many similar factors as possible, with the only discrepancy being in reading ability. One member of each pair is a normal reader; the other is disabled in reading. Following the matching procedure, various measures of auditory discrimination and/or acuity are administered to both "normal" and "subnormal" readers, and differences in auditory skills are analyzed.

An early study of this type was reported by Bond (1935). Sixty-four pairs of pupils from grades two and three who were matched with respect to sex, age, intelligence, and school experience were employed. Each pair differed primarily in reading achievement; "poor" readers were retarded by at least one-half year if enrolled in second grade, by at least one year if in third grade. Results showed significant differences in performance between "good" and "poor" readers on the tests of skill in auditory blending and auditory perception. Significant differences were found between the groups in auditory discrimination. An interesting additional finding was that auditory abilities appeared to be more highly related to reading achievement if pupils were taught by means of an oral-phonetic type of instruction.

A recent study involving the use of the matched-pairs technique was reported by Goetzinger, Dirks, and Baer (1960). This investigation utilized fifteen matched-pairs equated in terms of sex, chronological age, and intelligence, and also were found to be equal in visual acuity. The subjects, ranging in age from ten years, seven months, to twelve years, nine months, included fifteen male "normal" readers from the Kansas City, Missouri, public schools and fifteen boys of the same age who were attending a reading clinic class. All of the subjects were administered a word-pairs discrimination test, as well as two measures of auditory perception which required each subject to identify fifty monosyllabic words after hearing them spoken.

The analysis of the comparisons between "good" and "poor" readers demonstrated highly reliable differences between the groups in performance on the word-pairs test and on one of the perception instruments. This relationship was further accentuated by the obtained correlation coefficients of .56 and .58 between reading achievement and the word-pairs and perception tests, respectively. Performance on the other perception test, however, did not discriminate

between the two groups. One additional finding of interest was that the word-pairs test was not significantly related to either of the perception techniques. This would seem to indicate that the two measures of auditory discrimination were testing somewhat independent skills.

A few other investigations using similar techniques have been reported. Wolfe (1941) reported that her group of retarded readers, all of whom were eight and nine years old, was significantly inferior to a group of average readers in ability to discriminate between word pairs. Using the same type of instrument, Monroe (1932) found a group of thirty-two first-grade nonreaders to be significantly inferior to a group of unselected first-grade children, despite the fact that the nonreaders were more mature in both chronological and mental age. In addition, a group of 126 control children was significantly superior to a group of 269 reading-defect cases in ability to blend words orally in word-building. Monroe concluded that lack of precision in the discrimination of speech sounds may impede progress in reading. In a recent study, Thompson (1963) found that, out of the best twenty-four readers from a sample of second-grade pupils, sixteen had possessed adequate auditory discrimination upon entering the first grade the previous year. However, examination of the poorest twenty-four readers from the sample indicated that only one had demonstrated adequate skill in making auditory discriminations at the beginning of the first grade.

Correlation studies

Another technique for assessing the relation of auditory discrimination to reading ability is that of measuring the two skills simultaneously and then determining the relationships which exist between them. Some of these studies have utilized samples of disabled readers, while others have employed samples of unselected children.

Studies of disabled readers A number of research reports evolve out of a clinical situation in which an investigator collects extensive data on individual cases over a long period of time. From observation of disabled readers over a period of years, it is possible to postulate various correlates of reading disability. Schonell (1948), for example, reported some years ago that 38 per cent of the backward readers studied over a period of eight years demonstrated some degree of deficiency in auditory discrimination. Moreover, weakness in auditory

discrimination of speech sounds was stated as one of the most important and most frequently occurring causal factors in reading disability.

Quite similar findings were reported by Robinson (1946), following a thorough study of thirty disabled readers, who ranged in age from six years, nine months to fifteen years, three months. These reading disability cases, twenty-five of whom were boys, achieved Stanford-Binet intelligence quotients of eighty-five or above, and ranged in amount of retardation in reading from nine months to seventy-five months. Administration of an auditory discrimination test designed to test discrimination of vowels and consonants separately indicated that five cases had insufficient auditory discrimination of vowels and four cases had a similar deficiency with respect to consonants. It should be pointed out that only twenty-four of the thirty cases received the auditory discrimination test and as a result the corresponding percentages of deficiency in auditory discrimination were twenty-two and seventeen for vowels and consonants, respectively.

Another study (Poling, 1953) which involved reading disability cases at the University of Chicago Reading Clinic between 1944 and 1949, utilized the data from fifty-eight boys and twenty girls. Poling's survey included only subjects between the ages of eight and thirteen years with intelligence quotients ranging from 100 to 120. The data were treated by dividing the group of disabled readers into levels on the basis of performance on an auditory discrimination test. The "high" group included thirty cases who achieved a percentile rank of seventy or above on the test; the "low" group was composed of ten students who ranked below the thirtieth percentile on the same test. Following this sectioning of pupils on the basis of skill in auditory discrimination, comparisons were made between groups with respect to the number and type of errors made by each. Results indicated no significant differences on any of the tests; the pupils with weak auditory discrimination were no more likely to make vowel, consonant, or reversal errors, or to add or omit sounds in words than were their counterparts who possessed a greater degree of auditory discrimination skill. Poling concluded that auditory discrimination is not a widespread cause of inefficient word recognition.

Studies of unselected populations A research technique closely related to the study of clinical populations is the survey method, in which tests of reading ability and of auditory discrimination are administered

to a representative group of subjects with the purpose of establishing whether or not significant relationships exist between these two types of measures.

A study of this type was reported by Wheeler and Wheeler (1954). Using 629 children in the fourth, fifth, and sixth grade, auditory discrimination was measured in a number of ways. The various tests required each subject to *1*] discriminate typical word-pairs, 2] discriminate between paired sounded elements and determine whether each pair was the same or different (er-or, er-er, etc.), 3] select the one word from four which did not rhyme and 4] select, from a list of three sounds, the one sound which he had heard in a stimulus word previously pronounced by the examiner.

Results of Wheeler and Wheeler's study indicated that each of the measures of auditory discrimination was significantly related to reading achievement. However, the correlation coefficients were in the .30 to .40 range, leading the investigators to suggest that "it cannot be concluded that at the intermediate grade level a substantial relationship exists between silent reading ability and the ability to discriminate sounds in a spoken language situation." (Wheeler & Wheeler, 1954, p. 108)

Reynolds (1953) surveyed extensively the auditory characteristics of 188 fourth-grade children and found that auditory blending was unrelated to general reading ability and was only slightly related to word recognition skills. Auditory discrimination which involved differentiating between word pairs, however, demonstrated somewhat higher relationships with all aspects of reading achievement.

At least two other studies used fourth-grade pupils as the sample for investigations. Templin (1954), in a thorough study of 318 children from the Minneapolis public schools, administered various tests of auditory discrimination as well as a test of general reading ability. Correlation coefficients between reading ability and the various auditory discrimination tasks were found to fall in the range, .22 to .47. The correlation of reading with word-pairs discrimination was .22; with writing consonant sounds, .25; with recognizing a sound in a specific position within a word, .40; with recognizing a sound in a specific position in a nonsense word, .44; and with recognizing a word containing a given sound, .47. Only the last-named measure, however, significantly discriminated between a contrasted group of "good" and "poor" readers. Mulder and Curtin (1955) found a significant

correlation coefficient of .44 between a measure of auditory blending and general reading ability for a fourth-grade group.

A study utilizing somewhat different techniques was reported by Harrington and Durrell (1955) in surveying approximately five hundred parochial school second-grade pupils in Boston. The auditory discrimination instrument which was administered in this study tested the child's ability to notice initial consonant sounds, rhyming at the ends of words, final consonants, and a combination of initial and final consonants in words spoken by the examiner. The design of the Harrington-Durrell study made use of a variation of the pairing technique in that pupils were paired on the basis of their being similar on each of three experimental variables, but marked different on the variable being studied. Therefore, pupils were matched with respect to mental age, visual discrimination, and phonics ability. At the same time, each pair differed widely in auditory discrimination skill, which made possible the comparison of reading ability among pupils of "high" and "low" auditory discrimination. Highly significant differences were found, indicating that pupils with superior auditory discrimination were likewise superior in reading ability. The study was later replicated with a group of one thousand second-grade pupils in Oklahoma and Kansas. Again, significant differences in reading ability were noted between the groups of "high" and "low" auditory discrimination pupils.

One other report from the literature should be mentioned because it summarizes the results of a number of investigations of the auditory discrimination factor at Boston University. Durrell and Murphy (1953) report that one of these related studies investigated the relationship of ability to identify sounds in spoken words to reading achievement in grades one, two, and three. Correlations between the auditory analysis ability and reading achievement were reported to be .56, .52, and .52 in grades one, two, and three, respectively. On the basis of this study in conjunction with a number of related studies, Durrell and Murphy conclude that the ability to notice the separate sounds in spoken words is a highly important factor in determining a child's success in learning to read.

Predictive studies involving first-grade pupils

Included in the vast amount of research devoted to the study of reading readiness are a substantial number of studies which report

the predictive relationship of performance on specific tasks of auditory discrimination given during the pre-reading period and subsequent success in first-grade reading. In this area of research, two of the most prominent names are Gates and Wilson, both of whom studied readiness for reading extensively in the decade from 1930 to 1940.

In a study which began in 1934 (Gates, Bond, & Russell, 1939), four New York City public school first-grade classes were administered tests involving almost every suggested means of appraising reading readiness, including a number of auditory discrimination tasks. Correlations between each of the auditory discrimination tests and each of the reading achievement measures were computed midway through the first grade, at the end of the first grade, and midway through the second grade. Mean correlation coefficients were computed to give some idea of the relationship between each auditory instrument and general reading ability. The average correlations with reading achievement ranked according to size were *1*] giving words with the same or rhyming final sounds, .43, 2] giving words with stated initial sounds, −.41 (score in this test was the number of errors); 3] blending, .38; *4*] reproduction of nonsense words, .23; 5] giving letters for sounds, .21; and 6] discriminating word-pairs, .20.

A number of other studies of a similar nature by Gates and his associates were reported in the period 1936–1940. Gates and Bond (1936) reported that in a group of four first-grade classes, there were "fair" correlations between the readiness skills of word-pairs discrimination, reproduction of letter sounds and nonsense words, and giving letters for sounds, and subsequent success in beginning reading. They further stated that tests of blending and rhyming ability failed to discriminate between pupils who were failing or succeeding in reading.

Gates (1939a) reported the results of a study which related readiness to reading achievement of pupils in a number of classrooms in which reading instruction varied from giving very little emphasis to phonics to giving a great deal of emphasis to "sounding" techniques. Correlations between skill in rhyming and reading achievement ranged from −.07 to .67 for the various classes studied, while similar correlations involving blending ability and reading varied from .10 to .54. In general, the highest correlations were given by tests which measured abilities similar to those which children were going to be taught. Therefore, tests of auditory discrimination are more closely related to

later reading success in classrooms in which the teacher utilized phonics as an aid to recognition of words.

In the process of standardizing his readiness test, Gates (1940) administered a number of readiness measures to 218 pupils in eight New York City public schools. The only auditory test utilized was that of recognizing rhyming words, and this test correlated .28 with reading achievement at the end of the year.

Another series of studies was conducted at Teachers College, Columbia University by Wilson and his associates. A major part of this research used first-grade pupils from the Horace Mann School which enrolled pupils with an above-average socio-economic background. In addition, a great deal of the discussion of research findings appears to be based on the data from one particular classroom of twenty-five students in which relationships were expressed in terms of rank order correlation coefficients, a somewhat imprecise technique for evaluation purposes. In view of these shortcomings, the studies by Wilson should be interpreted cautiously.

Wilson's research, which was conducted in the 1930's, was summarized by Kopel (1942). In discussing all of the tests which were administered by Wilson and his associates and subsequent computation of more than two thousand correlation coefficients, Kopel remarked that results on the whole were disappointing and that even the highest correlations were inadequate for predicting later reading attainment with any satisfactory degree of accuracy. Kopel did state, however, that significant relationships were found between first-grade reading success and certain abilities with letter forms and sounds. For example, giving letters for letter sounds correlated approximately .70 with reading ability at the end of the year. Furthermore, in the various studies, the associated skills of giving initial and final sounds of words and blending letter sounds were substantially related to reading achievement with many rank order correlations reaching .60 or above. With respect to these relationships, it should be noted that in some cases the particular tests mentioned were administered in midyear rather than at the beginning of the first grade. As a result, in such situations the correlations indicated status relationships, not predictive relationships, and findings are not directly applicable to this discussion.

Another investigation (Steinbach, 1940) used as a sample three hundred entering first-grade pupils who were administered a

large number of readiness tests, including a word-pairs discrimination test, the only measure of auditory discrimination. Results showed this test to rank second of all of the readiness measures employed in terms of its relationship with reading achievement at the end of the school year ($r = .51$). Furthermore, the word-pairs test ranked first with respect to its contribution to a multiple regression equation for the prediction of midyear and end-of-year reading achievement.

In the standardization of the Reading Aptitude Test, Monroe (1935a) administered a number of readiness tests to 434 children in the primary grades. Correlation coefficients between each of the major types of readiness tests (visual tests, auditory tests, language tests, etc.) and end-of-first-grade reading achievement were computed on data from eighty-five children in four first-grade classrooms. Correlation between reading and a composite auditory score, including measures of blending, auditory memory, and correct pronunciations, proved to be .66, a higher relationship than that involving any other readiness factor. However, no correlations were computed for the individual subtests.

Conclusions from previous research

When comparisons are made between matched groups of "good" and "poor" readers, skill in auditory discrimination appears to be significantly related to achievement in reading. In other words, inferior auditory discrimination is a correlate of reading disability, even though present research does not warrant the inference of a cause and effect relationship.

Surveying the relationship between auditory discrimination skills and reading achievement by simultaneously measuring the two leads to different conclusions depending on the population studied. When the auditory discrimination abilities of disabled readers are examined, research is in general agreement that disabled readers are markedly deficient in these skills. However, examining relationships between auditory discrimination and reading achievement of unselected populations of elementary and secondary pupils results in inconclusive findings. Investigators using similar techniques report very different results ranging from substantial correlation relationships to no relationship at all. Furthermore, age does not seem to be a factor in determining whether or not skill in auditory discrimination is related to reading achievement. Studies involving pupils from grades two

through twelve appear to be equally inconclusive in trying to establish the extent of these relationships.

Studies which have attempted to assess the relation of auditory discrimination ability during the pre-reading period to future success in learning to read have generally reported small positive correlational relationships ranging from approximately .20 to .40.

Experimental procedures

In order to assess the relationship between auditory discrimination and subsequent reading achievement, selected measures of auditory discrimination were administered to a sample of first-grade pupils at the beginning of the school year, and reading achievement was measured at the end of the school year. Multiple regression and correlation techniques were employed to determine the extent and significance of the obtained relationships. In addition, the *t* test was used to evaluate mean differences in performance between boys and girls on each of the measures.

The sample

The sample used in this study consisted of eight schools in the Minneapolis Public Schools which included twenty-six first-grade classrooms numbering 386 boys and 338 girls. The eight schools were selected as a stratified random sample by the research department of the Minneapolis Public Schools. Each of the schools in Minneapolis is classified as high, middle, or low socio-economic level, according to specified weights based on three criteria: *1*] the per cent of homes owned by occupants, 2] the average amount of rent paid by renters, and 3] the per cent of days in school attendance in the most recent three years.

As a result of the sampling procedure, eight schools were selected to participate in the study. Three schools enrolling 204 first-grade pupils were classified as high socio-economic, three schools enrolling 279 first-grade pupils were classified as middle socio-economic, and two schools enrolling 241 first-grade pupils were classified as low socio-economic. The mean intelligence quotient for the total sample was 102 as measured by the Lorge-Thorndike Intelligence Tests (1957) administered at the beginning of the first grade.

As is to be expected in any longitudinal study, a number of cases was lost during the course of the investigation. From the original

total of 724 first-grade children (386 boys, 338 girls) at the beginning of the study in September, complete data were gathered on 632 cases (331 boys, 301 girls). Some of the cases were lost during the fall testing, while others moved out of the school system in the interim between the completion of fall testing and the beginning of the achievement testing in the spring, and were, therefore, eliminated from the study. However, every subject who had taken the entire battery of tests in the fall and had later transferred to another school within the Minneapolis Public Schools was followed up and administered the spring achievement tests. Those cases who transferred to other school systems were not contacted and were lost to the study.

In order to determine whether or not the lost cases could be considered to be representative of the sample as a whole, the mean achievement and variability of these cases was compared with the mean achievement and variability of the cases who persisted. Utilization of the *t* test revealed that the hypothesis of no differences between means of drop-outs and persists on the intelligence test and the auditory discrimination measures was accepted in each case except one. Girls who persisted scored significantly higher on the first auditory subtest of the Reading Aptitude Tests. This hypothesis of no differences was tested by means of the F test. Again the analysis revealed the two groups to be similar except for one instance. The boys who were lost to the study were significantly more variable in chronological age than were the boys who persisted. Therefore, there is little reason to suspect that failure to obtain complete data on all pupils who comprised the preliminary sample in any way biased the findings of the investigation.

Selection and administration of tests

The instruments used to test auditory discrimination were selected subtests from published reading readiness tests. Intelligence was measured by means of the Lorge-Thorndike Intelligence Tests (1957). Reading ability at the end of the first grade was assessed by use of the word recognition and paragraph reading subtests from the Gates Primary Reading Test (1958). Information concerning each of the measures including a statement of its purpose is given in Table 1.

With one exception, all tests were administered by the investigator or by one of four advanced graduate students. One member of the testing team served in each classroom as the test administrator

Table 1 Summary of information on measuring instruments used

Name of test	*Test battery from which test was selected*	*Ability tested*
Rhyming Test (14 items)	Gates Reading Readiness Test, 1939	to detect rhyming elements at the ends of words
Making Auditory Discriminations (16)	Harrison-Stroud Reading Readiness Profiles, 1956	to discriminate between spoken words which do or do not begin with identical sounds
Using Context and Auditory Clues (18)	Harrison-Stroud Reading Readiness Profiles, 1956	to use auditory clues with context clues in the identification of strange words
Auditory Discrimination of Beginning Sounds[a] (20)	Murphy-Durrell Diagnostic Reading Readiness Test, 1949	to recognize similarities and differences in the beginning consonants and blends of words
Auditory Discrimination of Ending Sounds[a] (20)	Murphy-Durrell Diagnostic Reading Readiness Test, 1949	to recognize similarities and differences in final consonants and rhymes
Discrimination of Correct Pronunciation[a] (9)	Reading Aptitude Tests, 1935 (by Marion Monroe)	to identify correct pronunciations of words
Auditory Blending[a] (12)	Reading Aptitude Tests, 1935	to discriminate sounds accurately and to blend the words in word-building
Form B, Level One, Lorge-Thorndike Intelligence Tests (65)	Lorge-Thorndike Intelligence Tests, 1957	
Word Recognition (48)	Gates Primary Reading Test, 1958	to read words representative of the primary vocabulary
Paragraph Reading (26)	Gates Primary Reading Test, 1958	to read representative primary grade passages with "reasonably thorough understanding"

[a] Tests were not named within test batteries and the name given is original with the writer.

and another member of the testing team and/or the classroom teacher assisted. The Gates Readiness Test was administered by the classroom teacher as part of the school's regular testing program. Testing periods varied in length from fifteen to thirty minutes and no more than two subtests were administered during any one testing session.

The tests designed to measure auditory discrimination abilities were administered in random order during the first four weeks of school. Follow-up of children who missed any of the tests was done in the succeeding two weeks, at which time the intelligence test was also administered. Prior to the beginning of the testing program, each of the graduate students administering the tests participated in a short training period during which he practiced giving the tests to two classrooms of first-grade pupils at Sidney Pratt School in Minneapolis.

With one exception, the tests were administered exactly as

outlined in the manual for that test. Some changes were made in administering the Murphy-Durrell Test. Although the test has just one auditory subtest, this particular subtest was split for purposes of the investigation. In its original form, the subtest is made up of 48 items designed to test ability to discriminate beginning sounds and 36 items designed to test ability to discriminate ending sounds. In this investigation each of these two sections of the auditory subtest was considered an independent variable. Furthermore, only twenty items were used for each test in order to make the measures somewhat comparable in length to the other auditory discrimination subtests utilized in the study.

The word recognition and paragraph reading subtests from the Gates Primary Reading Test were administered during a two-week period in May. Follow-up of absentees and children who had transferred to other schools within the Minneapolis Public Schools was done immediately after this period. Administration of the achievement tests was handled in every instance by the investigator or by one of the four advanced graduate students.

Analysis and results

The analysis of the data involved calculating correlation coefficients and multiple regression equations separately for boys and girls as well as for the total sample in which the sexes were combined. In the analysis which involved testing whether observed relationships between variables or observed differences between boys and girls were statistically significant, the four general questions posed previously were translated into the appropriate null hypotheses. For example, question one was translated into a set of null hypotheses which stated that there were no differences between boys and girls in mean intelligence, mean reading performance, mean chronological age, and mean performance on each of the auditory discrimination measures. In testing these hypotheses the .01 level of significance was used. However, test statistics with a probability of occurrence of .05 or fewer were indicated.

The variables employed in the study were given *X* and *Y* designations and are listed in Table 2. The pre-reading measures (intelligence, chronological age, and auditory discrimination) have been designated the *X* variables and are also referred to as independent

Table 2 Variables included in the investigation

Independent variables	*Dependent variables*
X_1 Chronological age	Y_1 Gates Word Recognition
X_2 Lorge-Thorndike Intelligence	Y_2 Gates Paragraph Reading
X_3 Gates Rhyming	
X_4 Harrison-Stroud Making Auditory Discriminations	
X_5 Harrison-Stroud Using Context and Auditory Clues	
X_6 Murphy-Durrell Discrimination of Beginning Sounds[a]	
X_7 Murphy-Durrell Discrimination of Ending Sounds[a]	
X_8 Reading Aptitude Pronunciation[a]	
X_9 Reading Aptitude Blending[a]	

[a] These tests were not named by the test authors; the names were provided by the investigator.

variables. The reading achievement measures have been designated the Y variables and are also referred to as dependent variables.

Analysis of sex differences

This aspect of the analysis utilized *t* tests to answer the question of whether or not boys and girls constituted a common population with respect to mean performance on the pre-reading measures and mean achievement in reading at the end of first grade. The results of the tests of the various null hypotheses are reported in Table 3.

Table 3 Tests of homogeneity between boys and girls in readiness for reading and in reading achievement

Variable	*Boys' mean*	*Girls' mean*	*Standard error*	*t*	*Hypothesis*
X_1 (C.A.)	76.5	75.5	.323	3.10	Reject *
X_2 (I.Q.)	101.1	102.8	1.098	1.55	Accept
X_3 (Gates)	11.0	11.9	.250	3.60	Reject *
X_4 (H-S_1)	10.6	11.2	.229	2.62	Reject *
X_5 (H-S_2)	9.5	10.3	.272	2.94	Reject *
X_6 (M-D_1)	14.1	14.6	.257	1.94	Accept
X_7 (M-D_2)	13.2	13.4	.241	.83	Accept
X_8 (Monroe$_1$)	6.2	6.3	.155	.65	Accept
X_9 (Monroe$_2$)	6.2	6.4	.147	1.36	Accept
Y_1 (Gates W.R.)	24.5	28.3	1.062	3.58	Reject *
Y_2 (Gates P.R.)	12.8	15.6	.492	5.70	Reject *

* Statistically significant at .01 level

The findings presented concur with the general conclusion from related research that girls are more mature in readiness for reading at the beginning of first grade. Of the seven measures of auditory discrimination, girls were significantly superior in three (Gates Rhyming, Harrison-Stroud Making Auditory Discriminations, and Harrison-

Stroud Using Context and Auditory Clues), while boys failed to hold an advantage in any. Moreover, girls were significantly younger at the beginning of first grade while the two sexes were equal in intelligence. Highly reliable differences were also found in mean word recognition and paragraph reading achievement at the end of the first grade. This finding, too, is in general agreement with previous research.

One further point deserves mention. Each of the auditory discrimination measures which demonstrated significant differences in favor of girls (X_3, X_4, and X_5) also made significant contributions to the multiple regression equations computed to predict word recognition and paragraph reading abilities of the total sample of boys and girls combined. However, of the four auditory discrimination tasks which did not differentiate significantly between boys and girls, only two (X_7 and X_8) made significant contributions to the prediction of reading achievement. Apparently, the measures which were most highly related to reading success were also measures of skills in which girls excelled.

The correlation analysis

This aspect of the analysis was designed to determine the extent of the relationships which existed among the various readiness measures, between the two reading measures, and between each readiness measure and each measure of reading achievement. Correlation matrices were constructed for boys and girls separately, as well as for the total sample in which the sexes were combined. Relationships were expressed as Pearson product-moment correlation coefficients and the *t* test was used to determine whether each of the relationships was significantly different from zero.

The intercorrelations among independent or readiness variables for boys, girls, and the total sample are presented in columns X_2 through X_9 and in rows X_1 through X_9 of Table 4, Table 5, and Table 6. An examination of Tables 4 and 5 reveals striking similarities between comparable correlation coefficients. Relationships among the auditory discrimination measures, intelilgence, and chronological age were of approximately the same magnitude for boys and girls. Furthermore, these same tables along with Table 6, which presents correlations based on the combined sample, point out the relative independence of the pre-reading measures. Although seven of the independent measures purported to test auditory discrimination, intercorrelations among

Table 4 Correlation relationships among variables for boys

Variable	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	Y_1	Y_2
X_1 (C.A.)		−.073	.131*	.003	.082	−.004	−.015	.052	−.051	.039	.017
X_2 (I.Q.)			.287**	.404**	.370**	.140*	.022	.299**	.258**	.437**	.426**
X_3 (Gates)				.346**	.323**	.097	−.020	.158**	.213**	.338**	.317**
X_4 (H-S_1)					.522**	.266**	.071	.183**	.307**	.434**	.428**
X_5 (H-S_2)						.243**	.131*	.263**	.187**	.474**	.422**
X_6 (M-D_1)							.410**	.116*	.117*	.198**	.217**
X_7 (M-D_2)								.112*	.062	.226**	.232**
X_8 (Monroe$_1$)									.216**	.379**	.349**
X_9 (Monroe$_2$)										.193**	.191**
Y_1 (Gates W.R.)											.795**
Y_2 (Gates P.R.)											

* Statistically significant at .05 level
** Statistically significant at .01 level

Table 5 Correlation relationships among variables for girls

Variable	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	Y_1	Y_2
X_1 (C.A.)		−.117*	.095	.073	.136*	.130*	.118*	.172**	.074	−.013	.022
X_2 (I.Q.)			.332**	.370**	.340**	.221**	.161**	.434**	.322**	.414**	.406**
X_3 (Gates)				.292**	.352**	.104	.045	.277**	.241**	.328**	.294**
X_4 (H-S_1)					.559**	.325**	.195**	.348**	.288**	.414**	.396**
X_5 (H-S_2)						.255**	.187**	.303**	.238**	.373**	.345**
X_6 (M-D_1)							.393**	.221**	.121*	.222**	.201**
X_7 (M-D_2)								.220**	.172**	.191**	.131*
X_8 (Monroe$_1$)									.367**	.440**	.382**
X_9 (Monroe$_2$)										.275**	.280**
Y_1 (Gates W.R.)											.734**
Y_2 (Gates P.R.)											

* Statistically significant at .05 level
** Statistically significant at .01 level

Table 6 Correlation relationships among variables for the total sample

Variable	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	Y_1	Y_2
X_1 (C.A.)		−.099*	.095*	.023	.092*	.048	.043	.103*	−.003	−.002	−.009
X_2 (I.Q.)			.311**	.391**	.359**	.180**	.089*	.362**	.290*	.457**	.418**
X_3 (Gates)				.331**	.347**	.110*	.016	.214**	.233**	.348**	.328**
X_4 (H-S_1)					.545**	.300**	.135**	.264**	.303**	.432**	.423**
X_5 (H-S_2)						.255**	.161**	.284**	.217**	.434**	.397**
X_6 (M-D_1)							.403**	.168**	.124**	.218**	.221**
X_7 (M-D_2)								.166**	.177**	.212**	.185**
X_8 (Monroe$_1$)									.288**	.408**	.362**
X_9 (Monroe$_2$)										.238**	.243**
Y_1 (Gates W.R.)											.771**
Y_2 (Gates P.R.)											

* Statistically significant at .05 level
** Statistically significant at .01 level

them were consistently low, almost always below .40. Moreover, the auditory discrimination measures were related to intelligence to only

a moderate degree and to chronological age slightly, if at all. In fact, correlations between chronological age and the various auditory discrimination tasks ranged for the total sample from —.003 to .095, certainly a negligible relationship. In this study older first-grade children exhibited no greater skill at making auditory discriminations than did their younger counterparts.

The correlation between the word recognition and paragraph reading tests is presented in the column designated Y_2 and the row designated Y_1 of Tables 4, 5, and 6. The intercorrelation of the two measures of reading ability based on the total sample was .77, a far greater relationship than that exhibited by any other pair of measures in the matrix. This finding lends support to the hypothesis that reading skills at the first-grade level are highly interrelated.

The correlations between each pre-reading measure and each of the two measures of reading ability are reported in the last two columns of Tables 4, 5, and 6. These correlations indicate the relative efficiency of predicting achievement in word recognition or paragraph reading on the basis of performance on each of the readiness measures. Examination of the appropriate columns of Table 6 indicates that the comparable pairs of correlation coefficients are strikingly similar for the total sample. The various readiness tests were related to each of the reading tests to a similar extent. This was not surprising, however, in light of the high intercorrelation which was found between the measures of word recognition and paragraph reading. The correlations ranged in value from .00 to .46 with only six exceeding .40. Chronological age was unrelated to reading ability while intelligence and the auditory discrimination tasks were significantly related to each of the reading tests. However, the relatively low correlations obtained cast doubt as to how much practical significance can be attached to these findings.

The multiple regression analysis

Multiple regression analysis was utilized to determine *1]* the best combination of readiness measures for predicting each of the measures of reading achievement, 2] the extent and significance of the relationship between each pre-reading measure and each of the measures of reading achievement, and 3] the effectiveness of each multiple regression equation in predicting word recognition or paragraph reading ability.

Developing the multiple regression equations Multiple regression equations for predicting word recognition and paragraph reading ability were computed separately for boys and girls and were also computed using the data from the combined sample. The first step in this procedure was the calculation of a multiple regression equation including all independent variables which were significantly related to the criterion. The calculation of this equation was performed by an IBM 7070 computer in accordance with a program devised by Lotto (1961). This program operates in a stepwise fashion, first selecting and computing the necessary statistics for the single *best* independent variable. It then selects the *best* of the remaining variables, from which the first variable has been partialed out. This process continues until the program has selected the optimum set of variables, each of which has satisfied a specified criterion of significance. In addition, at each step the program may delete from regression any independent variable which is no longer significant because of additional variables entering into regression. At each step of the program, information is available pertaining to 1] the value of the multiple correlation coefficient, 2] the test of significance for the multiple correlation coefficient, 3] the value of the partial and standard partial regression coefficients for each independent variable, and 4] the tests of significance for these coefficients.

The significance of the relationship between the combination of variables represented by the multiple regression equation and reading achievement was evaluated in terms of R, the multiple correlation coefficient. The hypothesis that the multiple correlation coefficient was not significantly different from zero was performed by means of the F test.

The relationship between each readiness measure and each reading achievement measure was expressed by a partial regression coefficient. This coefficient expresses the average change in the dependent variable, in this case one of the measures of reading achievement, per unit change in the independent variable while partialing out the effect of all other independent variables. A test was made to determine whether or not each partial regression coefficient represented a relationship significantly different from zero.

The standard partial regression coefficients and the corresponding multiple correlation coefficients for the two equations which were computed to predict word recognition and paragraph reading

abilities of the sample of boys and girls combined are presented in the last two columns of Table 7. Similar information concerning the equations computed separately for boys and girls is recorded in the same table. The similarity of the standard partial regression coefficients

Table 7 Standard partial regression coefficients, multiple correlation coefficients and coefficients of determination for the six multiple regression equations

Readiness measures	*Girls* Y_1	Y_2	*Boys* Y_1	Y_2	*Total* Y_1	Y_2
X_1 Chronological age	−.0801*	—	—	—	—	—
X_2 Intelligence	.1468**	.1792**	.2653**	.2076**	.2193**	.1949**
X_3 Rhyming	.1241**	.1087**	.1265**	.1238**	.1320**	.1285**
X_4 Making Auditory Discriminations	.1746**	.2237**	.1359**	.1832**	.1518**	.1812**
X_5 Using Context and Auditory Clues	.1136**	—	.1937**	.1399**	.1525**	.1214**
X_6 Discrimination of Beginning Sounds	—	—	—	—	—	—
X_7 Discrimination of Ending Sounds	—	—	.1669**	.1789**	.1125**	.0942**
X_8 Pronunciation	.2606**	.1835**	.1854**	.1775**	.1987**	.1665**
X_9 Auditory Blending	—	—	—	—	—	—
Multiple Correlation Coefficient	.576**	.525**	.657**	.607**	.619**	.571**
Coefficient of Determination	.35	.27	.44	.37	.38	.32

* Statistically significant at .05 level
** Statistically significant at .01 level

and the multiple correlation coefficients calculated for the six equations is readily apparent.

The question of whether the specific set of standard partial regression coefficients for each equation was significantly related to the reading measure it was designed to predict was interpreted in terms of R, the multiple correlation coefficient. In this study R described the correlation between the observed scores for the two measures of reading achievement and the scores predicted for each by the specific multiple regression equation. The test of the hypothesis that R was not significantly different from zero was rejected in both cases involving the total sample – the equations for predicting word recognition and paragraph reading abilities. As Table 7 indicates, R was also significantly different from zero in the pairs of equations computed separately for boys and girls. Therefore, each of the sets of regression coefficients was significantly related to reading achievement.

Comparing the multiple correlation coefficients for the prediction of word recognition and paragraph reading achievement of the total sample reveals a striking similarity between the two. This similarity is further indicated by the fact that exactly the same readiness measures were included in each multiple regression equation.

This finding reinforces the view expressed earlier that the two measures of reading achievement tested highly related skills.

Standard partial regression coefficients, rather than partial regression coefficients, are presented in Table 7 because the former are in standard score form and are, therefore, independent of the scale of measurement of the respective readiness measures. As a result, the size of each standard partial regression coefficient gives an indication of its contribution to the multiple regression equation. Therefore, reference to the listing of these coefficients in Table 7 reveals the relative contribution of each pre-reading measure to the multiple regression equations for reading achievement. Measures which are not represented by a standard partial regression coefficient in the table failed to make a significant contribution to the regression equations.

The data for the total sample in Table 7 reveal that intelligence and five of the seven auditory discrimination tasks were significantly related to both measures of reading ability. Chronological age, the Murphy-Durrell test designed to test ability to discriminate beginning sounds, and the blending subtest from the Reading Aptitude Test were not significantly related to either reading measure. Among those variables significantly related to reading ability, the Lorge-Thorndike Intelligence Test was consistently one of the best predictors. It received the highest weighting in predicting both the word recognition and paragraph reading of the combined sample.

The Making Auditory Discriminations subtest from the Harrison-Stroud Reading Readiness Profiles also predicted reading achievement consistently well when compared with the other pre-reading measures, except for the prediction of word recognition of boys. In each of the equations for predicting paragraph reading ability and in the equation for predicting word recognition of girls, this auditory discrimination test ranked first or second in its relative contribution to the equation.

The subtest from the Reading Aptitude Test which assessed the ability to select the correct pronunciation for a word was also a relatively good predictor of subsequent reading success. The other four variables which were included in some or all of the multiple regression equations were consistently less important to the prediction of either measure of reading achievement. Actually, these measures contributed very little to the accuracy of prediction in a practical sense as is pointed out in the following section of this report.

The effectiveness of prediction It has already been reported that each of the multiple regression equations developed to predict word recognition and paragraph reading abilities of boys and girls, separately and combined, was significantly related to the ability it was designed to predict. However, no attempt was made to report the practical significance of this finding.

The effectiveness of prediction of each equation may be discussed in terms of two related quantities. The coefficient of determination, designated R^2, is simply the square of the multiple correlation coefficient and it indicates the proportion of the sum of squares of the dependent variable which can be ascribed to variation in the independent variables. The coefficient of determination, then, is equal to the proportion of variation (measured by the sum of squares) of the reading measure which might be eliminated if all cases were selected to have the same readiness scores.

The coefficient of non-determination, designated $1 - R^2$, reveals the proportion of variation in the dependent variables which is independent of variation in the independent variables and must, therefore, be ascribed to other sources of variation. This term indicates the proportion of variation in the specific reading measure which would remain, even in a group with uniform readiness test scores.

Although the coefficients of multiple correlation were found to be significantly different from zero, a great deal of variability in the measures of reading achievement could not be explained on the basis of variability in the readiness measures. Table 7 reveals the coefficient of determination to be .38 with respect to the prediction of word recognition and .32 with respect to the prediction of paragraph reading. Therefore, only 38 per cent of the variability in word recognition scores could be ascribed to variability in the six readiness measures constituting the equation. This left 62 per cent of the variability unaccounted for and, therefore, related to other influences. By the same token, 32 per cent of the variability in paragraph reading scores was related to variability in the six readiness measures, and 68 per cent of the variation was unaccounted for. Evidently, reading success is dependent upon many factors over and above the abilities measured in this investigation.

Another method of evaluating the effectiveness of a multiple regression equation is to compare the accuracy of prediction of equations utilizing various numbers of independent variables. The method

of calculating the multiple regression equations made possible some interesting comparisons. The equations were computed using Lotto's program for the IBM 7070 computer. This program operates by selecting the single best predictor variable and then proceeds to add independent variables to the equation one at a time according to their relationship to the dependent variable. As a result, it was possible to determine the increase in the effectiveness of prediction as a consequence of adding predictor variables to the equation.

Information pertinent to this problem is presented in Tables 8 and 9. These tables report data for the two equations computed for the total sample. Table 8 illustrates the increase in accuracy of prediction which resulted from adding additional variables to the single best

Table 8 The gain in efficiency in predicting word recognition achievement of boys and girls combined as a result of adding those variables which make a statistically significant contribution to the variable which is the single best predictor

Independent variable [a]	*Multiple R*	*Coefficient of determination*	*Net gain* [b]	*Coefficient of non-determination*
X_2	.46	.21	—	.79
$X_5 + X_2$	.54	.29	.08	.71
$X_8 + X_5 + X_2$	.58	.34	.05	.66
$X_4 + X_8 + X_5 + X_2$	.60	.36	.02	.64
$X_3 + X_4 + X_8 + X_5 + X_2$	.61	.37	.01	.63
$X_7 + X_3 + X_4 + X_8 + X_5 + X_2$	.62	.38	.01	.62

[a] Variables are listed according to their value predictors, beginning with X_2, which was the single best predictor.

[b] Net gain is interpreted as the gain in the proportion of variance accounted for as a result of adding the particular independent variable to the multiple regression equation.

predictor of word recognition, intelligence (X_2). Intelligence by itself accounted for 21 per cent of the variability associated with the dependent variable, word recognition, as expressed by the coefficient of determination. Adding X_4 to the equation increased the coefficient of determination to .29, while adding the four remaining significant variables increased it to .38. Adding four variables to the two *best* predictor variables produced an increase of only 9 per cent in the proportion of variability of the dependent variable which could be ascribed to variability in the independent variables.

Table 9 yields similar data with respect to the prediction of paragraph reading. The single *best* predictor of paragraph reading ability was X_4, the Making Auditory Discriminations test, which ac-

Table 9 The gain in efficiency in predicting paragraph reading achievement of boys and girls combined as a result of adding those variables which make a statistically significant contribution to the variable which is the single best predictor

Independent variable [a]	*Multiple R*	*Coefficient of determination*	*Net gain* [b]	*Coefficient of non-determination*
X_4	.42	.18	—	.82
$X_2 + X_4$	.50	.25	.07	.75
$X_8 + X_2 + X_4$	.54	.29	.04	.71
$X_3 + X_8 + X_2 + X_4$	.55	.30	.01	.70
$X_5 + X_3 + X_8 + X_2 + X_4$	.56	.31	.01	.69
$X_7 + X_5 + X_3 + X_8 + X_2 + X_4$	.57	.32	.01	.68

[a] Variables are listed according to their value as a predictor beginning with X_4, which is the single best predictor.

[b] Net gain is interpreted as the gain in the proportion of variance accounted for as a result of adding the particular independent variable to the multiple regression equation.

counted for 18 per cent of the variability associated with the dependent variable. Addition of the five remaining significant independent variables raised the coefficient of determination to a final level of .32. Similarly, the coefficient of non-determination decreased only from .82 to .64 as a result of adding five additional predictor variables to the multiple regression equation.

Summary and conclusions

This study examined the relationships between pre-reading measures of auditory discrimination and reading achievement at the end of first grade. Seven auditory discrimination subtests selected from published reading readiness tests were administered at the beginning of first grade and two subtests of the Gates Primary Reading Test were given at the end of the school year. Complete data were gathered on 632 pupils. Relationships were assessed by means of the Pearson product-moment correlation coefficient and multiple regression. Data were analyzed separately for boys and girls and were examined to determine whether or not sex differences existed in performance on the auditory discrimination measures and the reading achievement tests.

A number of conclusions can be drawn from this investigation. These conclusions are somewhat broader than the four questions posed originally but are closely related to them. In the first place, girls were significantly superior to boys in the auditory discrimination skills

measured. They were also superior in reading achievement after a year of instruction. However, this study indicates that the same auditory discrimination abilities were related to a similar degree to future reading ability of boys and girls. Boys apparently learned auditory discrimination skills less readily than girls and also took longer to master the reading process.

The findings of the correlation and multiple regression analysis contributed additional evidence to the unalterable conclusion that learning to read is an extremely complex task. Although every one of the tests of the ability to make auditory discriminations, as well as the intelligence test, was found to be significantly related to reading achievement, a combination of these measures still left a great deal to be desired as far as predicting the reading achievement of individual students was concerned. About all that is possible in the classroom is the making of gross discriminations between individuals who are likely to be successful in learning how to read and those who are likely to encounter difficulty. While information along these lines is certainly valuable to the teacher of first-grade reading, it can probably be obtained without administering an entire battery of readiness measures.

The present study also indicated that investigators are often somewhat imprecise when they speak of the relationships which exist between various auditory discrimination skills and reading achievement. The implication is clear that it would be much more appropriate to talk about the relationships which do or do not exist between certain test instruments (which have been designed to measure these auditory discrimination skills) and reading achievement. For example, in this study, two subtests measuring similar skills were utilized. The Harrison-Stroud Making Auditory Discriminations Test (X_4) asks pupils to draw a line between a stimulus picture and the one out of two response pictures which has a name beginning with the same sound. The Murphy-Durrell Discrimination of Beginning Sounds Test (X_6) instructs pupils to draw a cross on a given picture if the name of that picture begins with the same sound as a word pronounced by the examiner. If the beginning sounds are different, the child is told to make no mark whatsoever. Therefore, essentially the same skill, being able to determine whether or not two words begin with the same initial consonant sound, is measured by two somewhat different techniques. However, results of the study indicated that the Making Audi-

tory Discriminations test ranked second only to the intelligence test as far as its contribution to the prediction of reading achievement was concerned, while the Murphy-Durrell test was one of two readiness measures which failed to contribute significantly to any predictive multiple regression equation.

Furthermore, the correlation between these two tests was only .30, a very insignificant relationship in light of the similarity of the task the two tests were designed to measure. High performance on one measure was not necessarily associated with high performance on the other. A teacher rating a pupil's readiness in making auditory discriminations might well rate him high or low on these skills, depending on the measuring instrument used. If readiness tests are to be used for diagnostic purposes additional reliability and validity studies must be undertaken.

Educational implications

In view of the relatively low relationships found between the auditory discrimination abilities as measured by the instruments used in this investigation and success in learning to read, the first-grade teacher should not expect that developing auditory discrimination of her pupils will be sufficient to insure their success in mastering the reading task. The fact that a majority of the measures was significantly related to the two measures of reading achievement indicates that the ability to make auditory discriminations *may* contribute to success in learning to read, and that attention, therefore, should be given to instructing children along these lines. Of course, this recommendation is largely intuitive, since no direct cause and effect relationship has been shown to exist.

On the basis of the findings of this study, there is no justification for spending more than twenty or thirty minutes testing auditory discrimination ability of first-grade pupils if the teacher's goal is to predict who will be successful in learning to read. In fact, if intelligence test data are available there is little need to do additional testing. Very little improvement in the accuracy of prediction can be expected as a result of giving an entire battery of auditory discrimination tests rather than administering an intelligence test alone or one or two short auditory discrimination measures. Furthermore, the use of auditory discrimination tests for diagnostic purposes is a dubious practice

in light of the low intercorrelations found among those tests designed to measure essentially the same skill.

In a similar vein, since there is no guarantee that two tests, each designed to measure the same skill, are equally valid and/or reliable, this study lends additional support to the necessity of carefully selecting tests for classroom use. Teachers, on the basis of their familiarity with developmental characteristics of first-grade children, should examine available tests to determine which of them includes content and directions for administration most in line with the interests and capabilities of the typical first-grade pupil.

Furthermore, within the range of ages included in the classrooms studied, chronological age is not a factor in predicting success in beginning reading. Merely waiting for a child to mature chronologically does not insure success in learning to read.

Suggestions for further research

A major proportion of the research assessing the relationship of auditory discrimination abilities with reading achievement has been correlational in nature. Experimental studies are now needed. Groups comparable in these abilities at the beginning of first grade should be treated differentially, with one group receiving instruction directed at improving auditory discrimination while the other group is given pre-reading instruction of a placebo nature. Equalizing the time spent in direct instruction in reading while varying the nature (but not the extent) of readiness training would make possible less ambiguous statements regarding the influence of auditory discrimination abilities on subsequent achievement in reading.

There is also need for a factor analysis of auditory discrimination measures. Various instruments for testing the ability to make auditory discriminations now exist. It would be interesting to determine the nature and number of the factors which are subsumed under the general heading of auditory discrimination abilities.

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